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(54) Capacitive voltage divider

(57) A capacitive alternating voltage divider, e.g. for medium or high voltage, comprising the series circuit of at least two capacitors C_1, C_2, one of which (C_2) serves as a measuring capacitor from which the output voltage is derived is characterized in that the measuring capacitor is connected to a path S_1, R_L with a variable impedance and that control means F_1, D, B_L are present which react to a D.C. voltage component in the output voltage to reduce said impedance in the presence of a D.C. voltage component and to increase it in the absence of a D.C. voltage component.

Fig-1

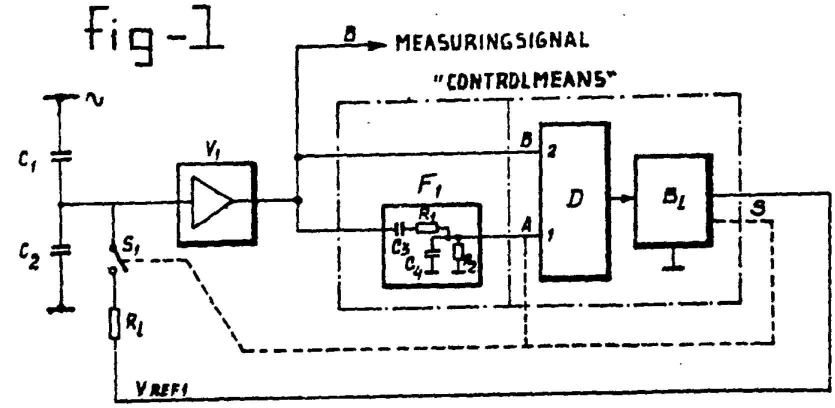

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Fig-1

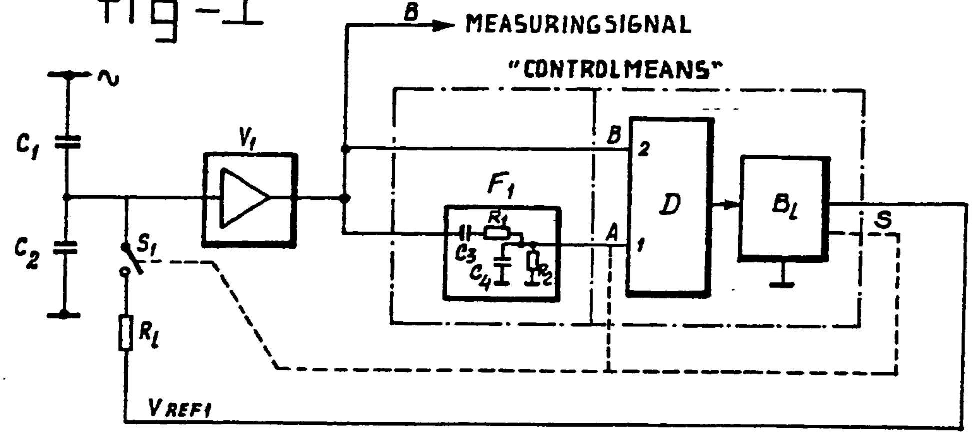

Fig-2

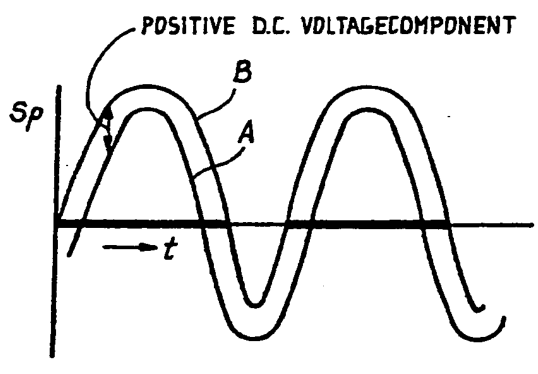

Fig-3

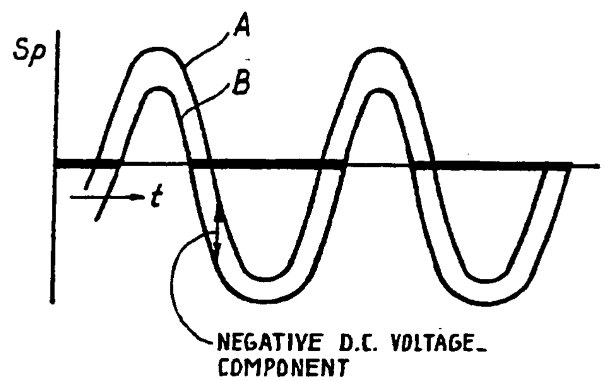

Fig-4

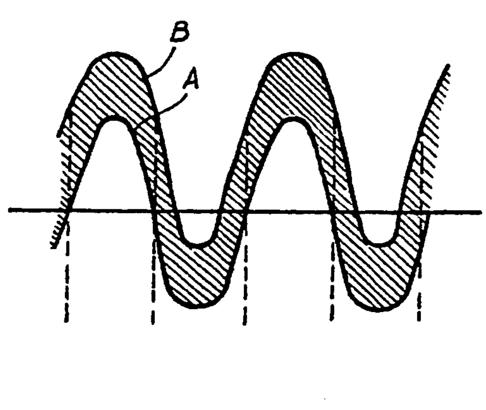

Fig-5

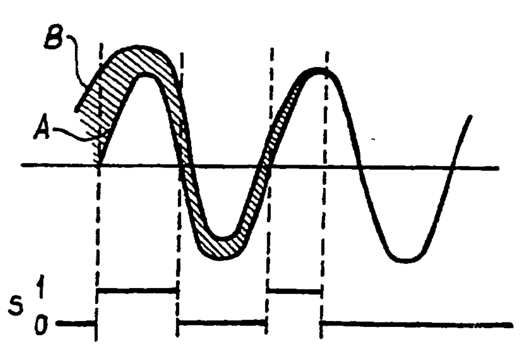

Fig-6

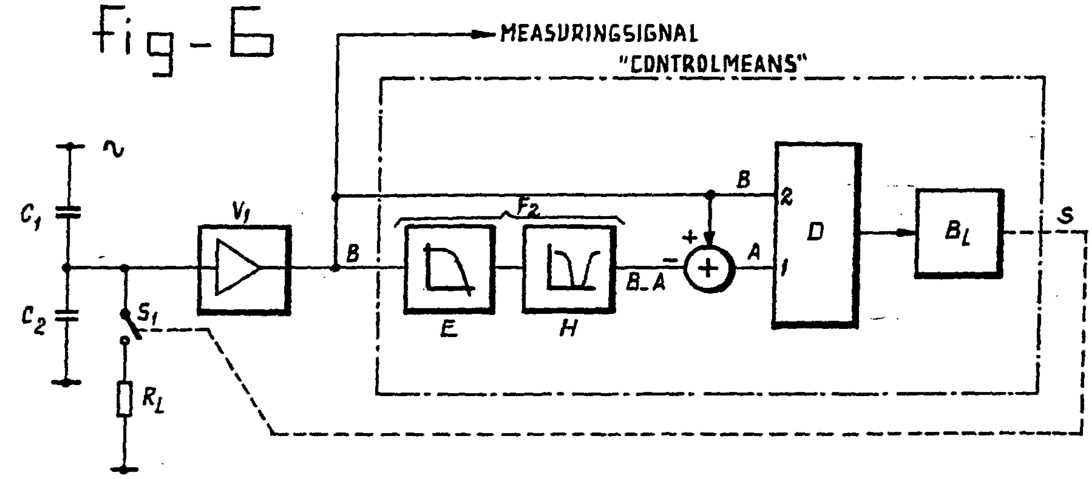
MEASURINGSIGNAL
"CONTROLMEANS"
~
C1
C2
S1
RL
V1
B
F2
E
H
B-A
+
-
A
B
2
1
D
BL
S

Fig-7

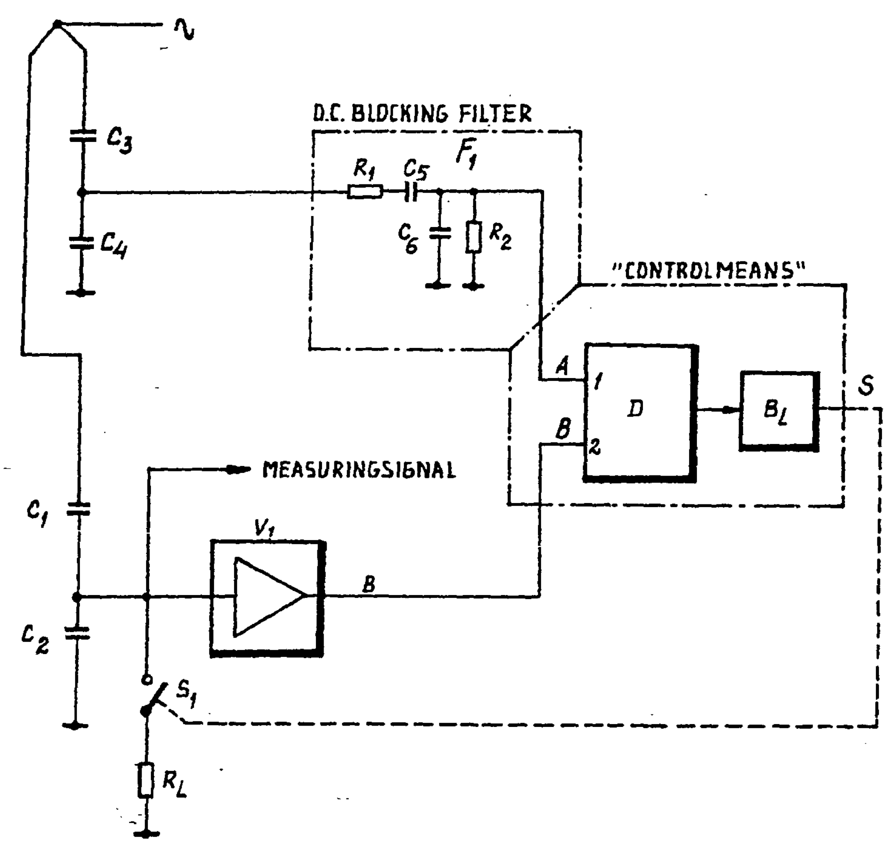
~
C3
C4
D.C. BLOCKING FILTER
F1
R1
C5
C6
R2
"CONTROLMEANS"
A
1
D
BL
S
B
2
MEASURINGSIGNAL
C1
V1
B
C2
S1
RL

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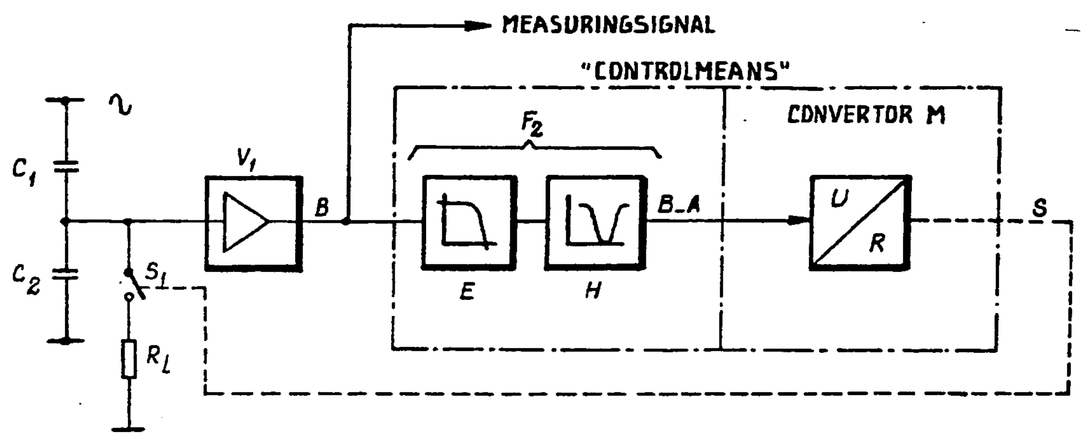
Fig-8



reference voltage on the other hand, and consisting of a series circuit of two capacitors. Such a circuit provides two input control signals for the comparison circuit.

However, when high voltage is involved, due to the application of a second capacitive alternating voltage divider in the latter circuit, two high voltage capacitors to be connected directly to the high voltage will become essential. With capacitive voltage dividers high voltage capacitors are generally integrated into the high voltage conductor system, so that the addition of a second high voltage capacitor may raise problems.

Therefore, in a further embodiment of the invention, use is again made of a single high voltage capacitor to be connected to the primary voltage while, between the high voltage capacitor and the reference voltage, a series circuit and/or parallel connection of several control capacitors is connected to supply the input control signals to the comparison circuit in the control means. With this embodiment, the capacitors may be given such values that the various secondary control voltages of the control capacitors will not or hardly affect each other. In this manner, the possibilities of applying the invention are considerably enlarged while an even more accurate and rapid operation is realised. One of the control capacitors may also form the measuring capacitor but this may also be a separate capacitor when a bridging by the adjustable leakage impedance is provided.

The invention will now be further illustrated with the aid of drawings in which as an example some embodiments are shown.

Figure 1 shows a capacitive voltage divider according to the invention, operating according to a first principle;

Figure 2 shows a graph of the true alternating voltage signal and the measuring signal with a positive D.C. voltage component;

Figure 3 shows a similar graph as given in Fig. 2 with a negative D.C. voltage component;

Figure 4 shows a graph of the signals supplied to the inputs of the comparison circuit, in explanation of the operation of the circuit according to Fig. 1;

Figure 5 shows the same signals as Fig. 4, but with a periodically reduced impedance of the member with a variable impedance;

Figure 6 shows a second embodiment of the circuit according to the invention;

Figure 7 shows yet another embodiment of the circuit according to the invention, in which a second series circuit of capacitors with two separate control capacitors is applied;

Figure 8 shows another embodiment of the circuit according to the invention, in which the impedance is switched pulse-wise;

Figure 9 shows another embodiment, in which two control capacitors separately connected in series and a high voltage capacitor are applied;

Figure 10 shows a variant of the circuit according to Fig. 9;

Figure 11 shows another variant of the circuit according to Fig. 9;

Figure 12 shows a further circuit according to the invention, with a high voltage capacitor and two control capacitors which are now embodied in parallel branches.

Fig. 1 shows a capacitive voltage divider consisting of a capacitor C_1 and a measuring capacitor C_2. Parallel to said measuring capacitor C_2 the member with variable impedance is connected, consisting of a switch S_1 and a leakage resistance R_L. Furthermore, both the measuring capacitor C_2 and the leakage resistance R_L are connected to a reference voltage. This may be the same reference voltage for both the measuring capacitor C_2 and the leakage resistance R_L, but these may likewise be different reference voltages.

The voltage divider consisting of the capacitors C_1 and C_2 acts as a wideband voltage divider as long as the switch S_1 is open. All phenomena, both rapid phenomena and D.C. voltages, are undistortedly supplied to the input with a high ohmic value of the wideband amplifier V_1. The output of said amplifier V_1, here merely arranged as a voltage following circuit, e.g. an emitter follower, produces the desired measuring signal B which is used for protective purposes.

When a D.C voltage component occurs in the measuring signal, the D.C. voltage blocking filter F_1 will discharge at a certain time constant, due to which the D.C. voltage component in the output signal A will rapidly disappear while, in the first instance, due to the switch S_1 being open, will remain on the input with a high ohmic value of the amplifier V_1 and, consequently, also in the measuring signal B.

Therefore, the output signal A of the D.C. voltage blocking filter, here a bandpass filter centered on the frequency of the desired alternating voltage, will after a brief period be a narrow band fundamental wave signal without a D.C. voltage component.

Together with the unmodified output signal B of the amplifier V_1, the output signal A of the D.C. voltage transmission filter is supplied as a control signal to a comparison circuit D, in which the control signals A and B are compared to each other. The comparison circuit D is coupled to a logical decisive circuit B_L. The output signal S of said decisive circuit may close the switch S_1 in the presence of a D.C. voltage component. This will be the case when the signal B is unequal to the signal A. As long as B is larger than A, the reference voltage $V_{ref.1}$ supplied to the member with a variable impedance should be smaller than B, and if B is smaller than A, said reference voltage should be larger than B. See Figs. 2

and 3, Fig. 2 indicating B as larger than A due to a positive D.C. voltage component and Fig. 3 indicating B as smaller than A due to a negative D.C. voltage component in the secondary voltage. A simple embodiment is that in which the reference voltages equal each other both for the measuring capacitor C_2 as for the leakage resistance R_L, e.g. O Volt. The switch S_1 may then be closed as long as B is larger than O if B is larger than A, or as long as B is smaller than O if B is smaller then A. In Figs. 2 and 3, the periods during which the switch S_1 is closed, are marked by the heavy-drawn lines of the horizontal axis. It has been proven in practice that, when A is larger than O (with B being smaller than A) the closing of the switch S_1 will enable a comparatively less complicated embodiment of the logical decisive circuit B_L. More effect is produced by the embodiment in which the reference voltage $V_{ref.1}$ for the leakage impedance or leakage resistance is varied or adjusted such that, e.g. by means of the logical decisive circuit B_L, that the said reference voltage $V_{ref.1}$ will always be smaller than B as long as A is not equal to B (when B is larger than A) and larger than B (when B is smaller than A). In the latter embodiment $V_{ref.1}$ is varied or adjusted either analogously or digitally. Here, for instance, the true alternating voltage signal A may also be used for the reference voltage.

The operation of the circuit according to Fig. 1 is further illustrated with the aid of Figs. 4 and 5. In Fig. 4 the case is shown in which the switch S_1 remains open even in the presence of a D.C. voltage on the measuring capacitor. The control signal A is the narrow-band fundamental wave signal, originating from the output of the D.C. voltage blocking filter while the control signal B is the alternating voltage signal with the D.C. voltage component originating from the amplifier V_1. As will be evident, this signal has been moved upwards with respect to the zero potential in the present example as a result of a positive D.C. voltage component on the measuring capacitor. Consequently, the zero passages of the leading and trailing edges of the control signal B are displaced with respect to the normal zero passages in accordance with the signal A, which may lead to the aforesaid control errors of the distance relays.

In Fig. 5 the case is shown in which the switch S_1 is each time closed by the logical decisive circuit during the positive half-periods of A, namely, because then B is larger than A and $V_{ref.1}$ equals O. At the foot of Fig. 5 the positions of the switch are shown, the reference number 1 indicating a closed switch and the reference number 0 an open switch. It is evident that, with a closed switch, the shaded residual voltage will disappear. During the negative half-period the switch is open and the r sidual voltage will remain present. During the subsequent half-periods, the switch is again closed and the residual voltage will completely disappear. Thereupon, the true alternating voltage signal will again appear from the amplifier V_1 without a D.C. voltage component. If, as reference voltage, a voltage analogous to the control signal A is used, the switch need not be opened during the negative half-periods. In this case, the residual charge will disappear also during the negative half-periods.

The bandpass filter applied in this example and acting as a D.C. voltage transmission filter, may be replaced by a high-pass filter. In series herewith, an all-pass phase correction filter may be incorporated for the purpos of correcting the frequency phase response.

Fig. 6 shows an exemplary embodiment with a D.C. voltage transmission filter F_2, consisting of a low-pass filter E and a bandstop filter H, the latter being centered on the frequency of the desired alternating voltage. The output signal (B–A) of the bandstop-filter is the wideband measuring signal from which, among other things, the desired alternating voltage component is filtered off, in other words, all undersirable components with frequenicies lower than the desired alternating voltage frequency are present in this signal. Upon inversion and summation with signal B, this signal (B–A) is used by the comparison circuit D to control the logical decisive circuit, as shown in Fig. 6.

Said inversion and summation may also be refrained from, the signal (B–A) being supplied directly to the input 1 of the comparison circuit D as a control signal. A reference potential, e.g. the voltage 0, should then be supplied to the input 2.

In Fig. 7, an embodiment is shown in which a second series circuit of capacitors is used for the purpose of diverting one of the input control signals to be supplied to the comparative circuit D. The signal on the junction of the high tension capacitor C_1 and the control capacitor C_2 is supplied to the amplifier V_1 producing the measuring signal B as an output signal which, in its turn, is again used as a measuring signal for the control of the protective device and, upon amplification in the amplifier V_1, is also supplied to one of the inputs of the comparision circuit as a control signal. This corresponds to the circuits applied in the embodiment discussed above.

However, a second capacitive voltage divider is now connected parallel to the capacitive voltage divider consisting of the series circuit of the capacitors C_1 and C_2, said second capacitive voltage divider consisting of the high voltage capacitor C_3 in series with a second control capacitor C_4. The signal on the junction of th capacitors C_3 and C_4, centered, via a D.C. voltage blocking filter F_1 (in the example represented a bandpass filter) on the desired alternating voltage frequency, is supplied to the input 1 of the comparison circuit

fig-9

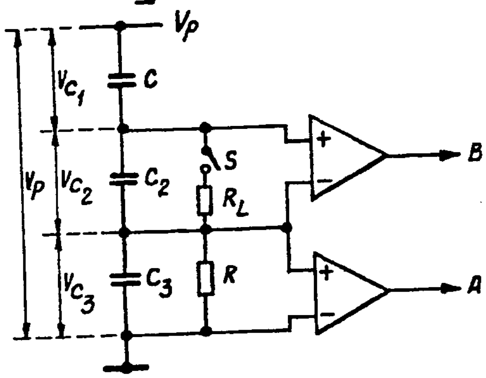
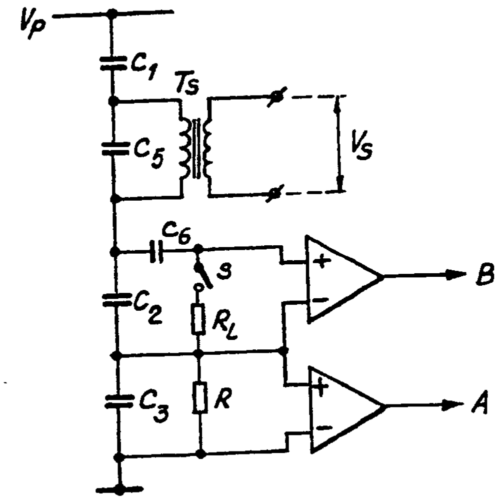


fig-10



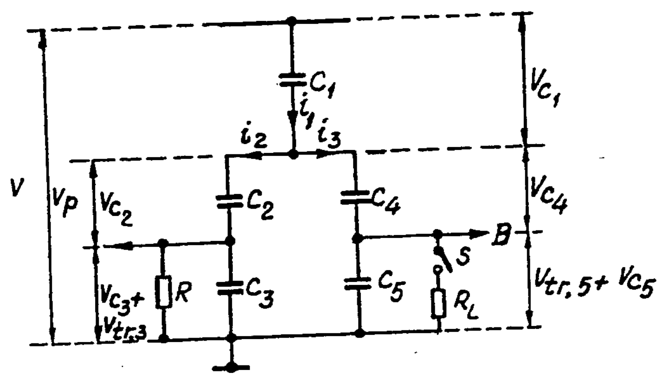


fig-11

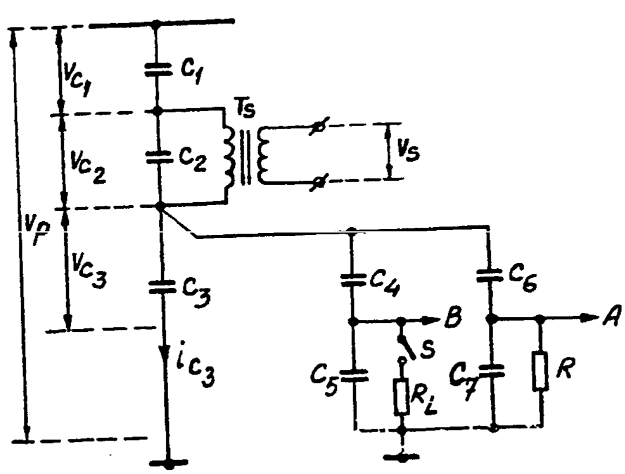


fig-12

SPECIFICATION

Capacitiv voltag divider

The invention relates to a capacitive alternating voltage divider, e.g. for medium or high voltages, comprising the series circuit of at least two capacitors, one of which serves as a measuring capacitor, which series circuit can be connected between a primary voltage and a reference voltage, a measuring signal being derived from the measuring capacitor as a secondary voltage.

A similar voltage divider is known from "Bulletin Scientifique A.I.M." 1973, June, pages 154–155. This known voltage divider is provided with a leakage impedance connected in parallel to the measuring capacitor in order to discharge the D.C. voltage occurring under certain circumstances over the measuring capacitor. Particularly, when the signal derived from the measuring capacitor—in the present case the measuring signal—serves to monitor the primary voltage connected to the voltage divider, a similar D.C. voltage over the measuring capacitor may render difficult, or even prevent the monitoring. In the presence of a similar D.C. voltage, distance relays cannot duly interfere or will interfere wrongly. Also, the localizing of an earth fault or phase short circuit will be difficult or even impossible.

A D.C. voltage over the measuring capacitor may occur, e.g. when a primary alternating voltage line is disconnected at a moment when the wave form of the alternating voltage does not pass through zero. The then remaining voltage on the line leads to a residual charge, also called D.C. voltage component, which will result in a D.C. voltage over the measuring capacitor via the capacitor connected to the primary voltage. If, with such a D.C. voltage over the measuring capacitor, the voltage should return after a few periods and a short circuit should occur immediately afterwards while the D.C. voltage is not yet sufficiently diverted, a zero passage of the measuring signal will consequently occur only after a few periods, to which zero passage a distance relay will react. However, this implies that they relay will react too late. Also, overvoltages on the primary alternating voltage lines may lead to residual charges and D.C. voltages over the measuring capacitor.

Therefore, for a correct operation of distance relays, an undistorted reproduction of the charges in the primary voltage will be essential. With the known voltage divider, a leakage impedance is connected parallel to the measuring capacitor for that reason, due to which the D.C. voltag will disappear with sufficient velocity.

The application of a leakage impedance will indeed prevent the occurrence of an inadmissible delay in the operation of protective means, a.o. under the conditions stated above, but an unfavourable effect of this measure is that phase shifts of the measuring signal will occur with respect to the primary alternating voltage. The result is a delayed response of protective means, e.g. in case of a short circuit in the primary alternating voltage circuit. Besides phase shifts, the measuring signal will also present transient phenomena as a result of the leakage impedance, which penomena, as will be understood, will likewise disturb an accurate operation of the protective system for the primary alternating voltage.

The aforesaid disadvantages are avoid d by the capacitive voltage divider according to the invention, characterized in that the measuring capacitor is connected to a member with a variable impedance and in that control means are present which react upon a D.C. voltag component in order to reduce said impedance in the presence of a D.C. voltage component and to increase it in the absence of a D.C. voltage component.

The invention is based upon the notion that the D.C. voltage over the measuring capacitor will not nearly occur in all cases and that, therefore, in the absence of said D.C. voltage, a leakage impedance may be omitted, so that an exact control of distance relays, if any, is guaranteed. Only in the presence of the D.C. voltage the impedance of the member connected to the measuring capacitor will be reduced to such an extent that the D.C. voltage is yet sufficiently rapidly diverted to prevent an excessive delay in the remote control.

In a further embodiment of the invention, the means reacting to a D.C. voltage may consist of a comparison circuit embodied in the control means, preceded by filters for the supply of the correct control signals to the comparison circuit, and followed by a logical decisive circuit controlling the member with variable impedance. The filters will enable the comparison circuit to distinguish a desired alternating voltage from other components, such as the D.C. voltage component. Generally, by means of the logical decisive circuit, the comparison circuit will lead to decrease the leakage impedance when voltage components are found which are unlike the desired alternating voltage. However, as control means, embodiments may also be chosen in which the presence of a D.C. voltage component is directly detected by diverting this from the secondary voltage via a D.C. voltage transmission filter. The D.C. voltage thus realised may be applied directly to control the variable impedance, e.g. by means of semi-conductor circuits.

One of the input control signals for the comparison circuit may also be diverted from a separate further capacitive alternating voltage divider, to be connected between the primary voltage on the one hand and the

D as a control signal A. If so required, a leakage resistance with a high ohmic value may be connected in parallel to the capacitor C_4 for the purpose of discharging residual charges on C_4. However, this resistance is not necessary for the operation of the D.C. voltage blocking filter.

Should a D.C. voltage component or charge occur on the measuring capacitor, this will not be supplied to the input 1 of the comparison circuit D as a result of the operation of the filter F_1 while, in the first instance, it will remain stationary on the input with a high ohmic value of the amplifier V_1 as the switch S_1 is still open. The comparison circuit D and the logical decisive circuit B_L will again operate in the manner according to the preceding exemplary embodiments and will switch on the switch S_1 when a D.C. voltage component will occur in the secundary voltage of the first divider.

It goes without saying that, here too, variations as regards the filters will be possible, like in the first mentioned exemplary embodiment. Thus, for instance, the output signal of a D.C. voltage transmission filter may be used directly for the operation of the switch S_1.

As a matter of course, the member with a variable impedance which, in the exemplary embodiments described above, generally consists of a series circuit of a resistance and a switch, may also be executed in a different manner. Thus, for instance, an impedance dependent on the output signal S of the logical decisive circuit may be applied.

Fig. 8 gives an example of an embodiment in which a converter M is applied, which converts the D.C. voltage (B–A) supplied from the D.C. voltage transmission filter into a pulse-shaped signal, the pulse/pause ratio of which depends upon the value of the D.C. voltage. Said pulse-shaped signal is supplied to the switch S_1 for the leakage impedance R_L. Therefore, when the filter F_2 detects a D.C. voltage the switch will be switched on and off until the D.C. voltage over de capacitor C_2 will have disappeared. If no D.C. voltage is present, the switch S_1 will remain open.

Instead of one single leakage impedance R_L and a switch S_1 connected in series therewith, several switches $S_1 \ldots S_N$ may be applied with corresponding leakage impedances $R_{L1} \ldots R_{LN}$, which, moreover, need not all have the same impedance value. By means of an A/D converter, the value of the D.C. voltage component is converted into digital signals which appear at the output and therewith operate the switches S_1 to S_N. If, for instance, the digital "One-out-of N" code is used, then, dependent on the value of the D.C. voltage compon nt, a certain leakage impedance will be engaged via the switch S_{Lm}, on the basis $1 \leq m \leq N$. Also, for instance, the impedances R_{L1} to R_{LN} inclusive may have equal values betw en them, no switch or one or more switches being switched on simultaneously, dependent on the value of the D.C. voltage component.

Also, the variation will be possible here that the respective reference voltages for the leakage impedance $R_{L1} \ldots R_{LN}$ are also controlled by the A/D converter.

As already remarked before, the member with a variable impedance, which so far consists of one or more impedances and one or more switches connected in series therewith, may also be executed as the internal resistance of a semi-conductor, e.g. a field-effect transistor. For instance, as a control voltage, the D.C. voltage (B–A) from the D.C. voltage transmission filter F2 may be supplied to this, either directly or via a voltage divider or impedance converter. Of course, the circuit should then be executed in such a manner, that the impedance of the semi-conductor will fall as the D.C. voltage (B–A) from the filter F_2 will rise.

Now, a few variants of the capacitive alternating voltage divider according to the invention will yet be described, in which the possibilities of application are enlarged and, like with the circuit according to Fig. 7, the two measuring signals will not affect each other and in which, furthermore, a better stability and a major regulation velocity may be achieved even though one high voltage capacitor will be sufficient.

These embodiments are based upon a method known per se, in which, by means of a capacitive alternating voltage divider, two measuring signals may be derived which ar highly mutually independent, said method being described in Proceedings of the I.E.E., Vol. 121, No. 12, December 1974, pages 1557–1566, particularly Fig. 13.

Here, it is started from a capacitive alternating voltage divider of the type as stated in the preamble of the present patent application, consisting of two capacitors in series, one of which serves as a high voltage capacitor while the measuring signal is diverted from the other capacitor via an impedance and a transformer. Now, said voltage divider is provided with a third capacitor connected in series and connected between the measuring capacitor and the reference voltage. The capacitance value of this third capacitor is chosen much higher than the capacitance values of the high voltage capacitor and of the measuring capacitor.

In this manner, the third capacitor will not or hardly affect the dynamic and static behaviour of the usual output voltage over the measuring capacitor while the output voltage over the third capacitor is a better reproduction of the primary voltage than the measuring voltage since the latter is diverted via a self-induction and a transformer.

However, this known capacitive voltage divider does not yet have the response meeting

the most recent requirements as to fiability and velocity. On the other hand, the systems according to the invention which are provided with a member with a variable band width acutally meet these requirements. Therefore, should the aforesaid systems be combined, a capacitive alternating voltage divider will be realised which, as already stated, will operate more accurately and swiftly.

With these two new embodiments, two different methods may be distinguished. The first is based upon the current source principle and may be applied with capacitive alternating voltage dividers, the high voltage capacitor of which has a capacitance value which is very low when compared to the value of the other series capacitors. Consequently, the current through the capacitive alternating voltage divider will remain very low and is entirely determined by the high voltage capacitor and the primary voltage. For instance, with a primary phase voltage of 240 kV, a high voltage capacitor with a value of 10 pF and a single measuring capacitor in series with a value of 0,2 μF, a current in the order of 0·75 mA will pass through while the voltage over the measuring capacitor will be 12 V. Therefore, instead of the high voltage capacitor, a current source in series with the measuring capacitor may be imagined. Consequently, this current will not be affected by any voltages acting the measuring capacitor and originating from circuits connected to said measuring capacitor.

Fig. 9 shows a practical embodiment of a similar capacitive voltage divider according to the invention, operating according to the current source principle. In series with C_1 and C_2, the latter of which will be called a control capacitor, a third capacitor C_3 is now incorporated, also a control capacitor, with a capacitance value of the same order of extent as that of the capacitor C_2. In this capacitive alternating voltage divider, too, the current through the high voltage capacitor through the control capacitors C_2 and C_3 is entirely determined by the high voltage capacitor C_1 which, for that purpose, should have a much lower capacity than the capacitors C_2 and C_3, said current also being almost independent on the voltages V_{C2} and V_{C3} which may appear across the capacitors C_2 and C_3 respectively.

The voltage V_{C2} is supplied to an amplifier and the amplifier output voltage acts as a wideband control signal B for a non-represented comparison circuit in accordance with the embodiments described earlier. Over the control capacitor C_2 which, in the present case, also acts as a measuring capacitor to provide the measuring signal, it is connected the member with variable impedance, consisting of the switch S and the leakage impedance R_1. The voltage V_{C3} occurring over the control capacitor C_3 will serve as control signal A after amplification and filtering and, therefore, will form the narrowband fundamental wav signal. In the mann r described above, both signals ar supplied to a comparison circuit, the output signal of which may operate the switch S. In the presence of a D.C. voltage component in V_{C2}, S will be closed. As a result of operating the switch S, equivalent transient voltages will occur over the control and measuring capacitor C_2 which, therefore, will also appear in the voltage V_{C2} and are not present in the primary voltage V_P. In an equal measure but with opposed polarity, these transient voltages are present in V_{C1} since $V_P = V_{C1} + V_{C2} + V_{C3}$, in which V_{C3} is much lower than $V_{C1} + V_{C2}$. Therefore, in V_{C3}, said transient voltages will be reproduced in a highly attenuated form. Therefore, V_{C3} is almost independent from V_{C2} and forms a more true replica of the true primary alternating voltage than the control signal A in the embodiments described in Figs. 1 to 6 inclusive.

The resistance R parallel to C_3 confers a high-pass character to the transmission function V_{C3}/V_P. If, for instance, the control signal A is conveyed through a low-pass filter, a band filter operation is obtained. However, the control signal A may also be conveyed through a phase correction filter as described in the embodiment according to, say, Fig. 6. Of course, the influence of R can no less or hardly be retraced in V_{C2} since the same argument prevails here as with the action upon V_{C3} by V_{C2}.

Therefore, in the manner as described above, control signals A and B may be created by means of a single alternating voltage divider with a high voltage capacitor C_1, the signal B also forming the desired measuring signal for protective purposes.

As shown in Fig. 10, giving a variant of the circuit according to Fig. 9, a capacitor C_5 may be incorporated between the high voltage capacitor C_1 and the first control capacitor C_2 for the purpose of diverting a further measuring voltage V_s by means of a transformer TS.

Whereas in the circuit according to Fig. 9 the capacity of the high voltage capacitor should be much lower than that of the two control capacitors, Fig. 10 states that the total capacity of the high voltage capacitor C_1 and the further capacitor C_5 must be considerably lower than the capacity of the control capacitors C_2 and C_3. In that case, here too, the current source principle applies. Generally, in this variant, C_2 must have a greater capacity than with the circuit according to Fig. 9 since, in this variant, C_1 already has a value higher than that of C_1 in Fig. 9. Consequently, the switching on of a leakage impedance R_L may be coupled with higher currents through the switch S. If, for this purpose, an electronic switch is applied, these higher currents are considered unfavourable.

This problem may be avoided by incorporating a further capacitor C_6 between the switch S and the junction of the two capacitors C_2

and C_6. If the capacitance value of C_6 is chosen much lower than that of C_2, the switch S can be operated by lower currents. With a closed switch S, C_6 and R_L will act as a high-pass filter. In the presence of a D.C. voltage across capacitor C_2, the switch S will be closed by the means as described above.

Consequently, via R_L, the capacitor C_6 is charged to the same voltage as across C_2. As soon as both voltages are equal, the switch S will open again, as a result of which the D.C. voltage over C_6 with opposite polarity is added to the D.C. voltage over C_2, in other words, the D.C. voltage over S now equals zero.

Fig. 11 shows another variant of the method operating according to the current source principle.

In this circuit, too, for a capacitive alternating voltage divider, a high voltage capacitor is applied only. Instead of in a series circuit, both control capacitors C_3 and C_5 are now in two separate parallel branches. Besides the control capacitor C_3 and C_5 respectively, each branch comprises the capacitor C_2 and C_4 respectively. With this circuit, the condition is that the capacitance value of the capacitors C_3 and C_5 is much higher than that of the capacitors C_1, C_3 and C_4. Again, the current through the high voltage capacitor and through both parallel branches is determined by the value of the high voltage capacitor C_1 and also, for each branch, by the value of the capacitors C_2 and C_4 respectively. Transient voltages V_{tr5} caused by e.g. the closing of the switch S for the purpose of diverting D.C. voltages, if any, over C_5 via R_L lead to a fraction

$$V_{tr}\ C_2\ (C_1 + C_2)/C_3\ (C_1 + C_2 + C_4)\ \text{in}\ V_{C3}$$

On the other hand, fraction

$$C_4\ (C_1 + C_2)/C_5\ (C_1 + C_2 + C_4)$$

only is perceptible of the influence of the resistance R in V_{C5} connected parallel to the control capacitor C_3.

This circuit has the advantage that the amplifier for the signal B has no "common mode" component, as is the case with the circuit according to Figs. 9 and 10. However, this circuit may have the disadvantage that the junction of C_1, C_2 and C_4 will be subject to a comparatively high voltage compared to the circuit according to Fig. 9 between the capacitors C_1 and C_2.

Fig. 12 shows a circuit with a high voltage capacitor operating according to the second method, which is based upon the voltage source principle. This circuit is particularly suitable for medium voltages. Capacitor C_2 and transformer TS providing the voltage V_s are not essential to the principle of the invention but may be applied for further protective purposes for the same reasons as with the circuit according to Fig. 10.

Although both control capacitors C_5 and C_7 are each incorporated in one of two parallel branches and, therefore, in accordance with the circuit according to Fig. 11, the present circuit does not operate according to the current source principle but according to the voltage source principle, and that under application of a capacitor C_3 with a value considerably higher than the capacity of the capacitors C_1 and C_2 and the sum capacity of $C_4 + C_5$ and C_6 and C_7 respectively. In this capacitive alternating voltage divider, the capacitor C_1 may have a value of 0·01 μF in a preferential embodiment for e.g. 10 kV, the capacitor C_2 a value of 0.033 μF and the capacitor C_3 a value of 1 μF. Consequently the current value through the capacitive voltage divider will be somewhat higher than in the voltage divider according to Fig. 9 since the capacities C_1 and C_2 will be higher.

C_1 and C_2 will indeed determine the current through the capacitive voltage divider but it is conceivable that, due to its higher capacity, the capacitor C_3 is replaced by a voltage source with the approximate no-load voltage

$$V_P\ C_1.C_2/(C_1 + C_2)\ C_3\ .$$

The current through the voltage dividers connected parallel to C_3 is negligible with respect to the current through C_3. Parallel to C_5, an adjustable leakage impedance is applied, consisting of a resistance R_L in series with the switch S for the purpose of discharging D.C. voltages occurring over C_5. S will then be closed by the means as descirbed above. In this manner, however, transient voltages will occur across C_5 which will occur in an equally strong measure and with opposite polarity across C_4 since V_{C3} is $V_{C4} + V_{C5}$ is constant because of the voltage source principle. In this manner the wideband control signal B is diverted, which acts as an input signal for the comparison circuit with two inputs according to the embodiments described earlier. Also, the signal B is used as a measuring signal for protective purposes.

The narrow band control signal A is diverted by means of the voltage divider C_6, C_7. Parallel to C_7, a resistance R is again applied in order to realise a high-pass character. Here, too, a band filter may be created by adding a low-pass filter. Again, the influence of R cannot be retraced in V_{C3} since disturbances, if any, will again appear over C_6 with opposite polarity, for, here too, $V_{C3} = V_{C6} + V_{C7}$ is of a constant value.

The capacitive voltage divider according to Fig. 12 may also be operated with a high voltage capacitor with a low capacitance value, e.g. 10 pF. In that case, the value 0.25 μF may be chosen for C_3, while the capacitors C_4 to C_7 inclusive will have a value of 3.2 μF each. With a primary voltage of 400 kV and

when omitting the capacitor C_2 in Fig. 12, a voltage of 20 V will then arise in the junction of the high voltage capacitor C_1 and the capacitors C_3, C_4 and C_6. The voltages A and B will then amount to 10 V each.

In the present case, it is conceivable that C_1 is replaced by a current source whereas C_2 is replaced by a voltage source. If C_1, the sum capacity of C_4 and C_5 and the sum capacity of C_6 and C_7 are chosen much lower than C_2, the measuring voltages A and B will affect each other only slightly.

It goes without saying that the invention will not be restricted to the embodiments represented here, but that additions and amendments will be possible without departing from the scope of the invention.

CLAIMS

1. Capacitive alternating voltage divider, e.g. for medium or high voltage, comprising the series circuit of at least two capacitors, one of which serves as a measuring capacitor, which series circuit can be connected between a primary voltage and a reference voltage, a measuring signal being derived from the measuring capacitor as a secondary voltage, characterized in that the measuring capacitor is connected to a member with a variable impedance and that control means are present which react to a D.C. voltage component in the secondary voltage for the purpose of reducing said impedance in the presence of a D.C. voltage component and to increase it in the absence of D.C. voltage component.

2. Voltage divider according to claim 1, characterized in that the control means consist of a comparison circuit, to one input of which it is supplied a true alternating voltage signal, derived from the secondary voltage, via a D.C. voltage blocking filter, and to a further input of which it is supplied a complete signal, corresponding to the secondary voltage, while the output signal of the control means controls the member with a variable impedance.

3. Voltage divider according to claim 1, characterized in that the control means consist of a comparison circuit, to one input of which it is supplied the D.C. voltage, derived from the D.C. voltage component in the secondary voltage, via a D.C. voltage transmission filter, a bandstop filter and adding means, and to a further input of which it is supplied a complete signal, corresponding to the secondary voltage, which complete signal is also supplied to said adding means while the output signal of the control means controls the member with a variable impedance.

4. Voltage divider according to claim 1, characterized in that the control means consist of a comparison circuit, to one input of which it is supplied the D.C. voltage, derived from th secondery voltage, via a D.C. voltage transmission filter, and to a further input of which it is supplied a reference potential, while the output signal of the control means controls the member with a variable impedance.

5. Voltage divider according to one of the preceding claims, characterized in that the true alternating voltage signal supplied to on output of the control means is derived from a separate second series circuit of at least two capacitors, to be connected between the primary voltage and the reference voltage, on of which capacitors serves as second measuring capacitor.

6. Voltage divider according to one of the preceding claims, characterized in that the member with a variable impedance consists of at least one switch connected in series therewith.

7. Voltage divider according to claim 6, characterized in that means are present which convert the control signal for the member with a variable impedance into a pulse-shaped signal, the pulse/pause ratio of which is proportional to the value of the D.C. voltage component, which pulse-shaped signal operates the switch.

8. Voltage divider according to one of the preceding claims, characterized in that the member with a variable impedance consists of several impedances, each of which is connected in series with a switch and that the control signal for the variable impedance switches one or more switches according to the value of the D.C. voltage component.

9. Voltage divider according to one of the preceding claims, characterized in that the member with a variable impedance is an active member with an adjustable impedance.

10. Voltage divider according to claim 9, characterized in that the active member is a semiconductor component.

11. Voltage divider according to claim 9, characterized in that the active member is an electronic tube.

12. Voltage divider according to one of the preceding claims, characterized in that the reference voltage applied to the member with variable impedance is regulated, both in height and in polarity, by the means serving for the operation of the member with variable impedance.

13. Voltage divider according to claim 12, characterized in that the reference voltage for the member with a variable impedance is operated by the logical decisive circuit and is always lower than the complete signal when the latter is larger than the true alternating voltage signal, and always larger than the complete signal when the latter is smaller than the true alternating voltage signal.

14. Voltage divider according to claim 13, characterized in that the reference voltage is the true alternating voltage signal.

15. Voltage divider according to claim 1, in which, in the series circuit, a high voltage capacitor is connected to the primary voltage,

characterized by a series circuit connected between the high voltage capacitor and the reference voltage and consisting of a first control capacitor providing a secondary voltage from which a narrowband fundamental wave signal is derived; a second control capacitor providing a complete secondary signal; comparison means enclosed by the control means, to an input of which the narrowband fundamental wave signal is supplied as a control signal, and to another input of which the complete secondary signal is supplied as a control signal, while the output signal controls the member with variable impedance, in which the capacity of the high voltage capacitor is considerably lower than the capacity of the other capacitor in the series circuit.

16. Voltage divider according to claim 1, characterized in that one of the control capacitors also forms the measuring capacitor to which the member with variable impedance is connected.

17. Voltage divider according to claim 16, characterized in that, between the junction of the high voltage capacitor with the first control capacitor and the member with variable impedance, a further capacitor is incorporated with a value which is considerably lower than the value of the first control capacitor.

18. Voltage divider according to claim 1 or 2, in which, in the series circuit, a high voltage capacitor is connected to the primary voltage, which high voltage capacitor is characterized by two parallel branches connected in series with the high voltage capacitor, each of which branches is provided with at least two capacitors connected in series, one of each forms a control capacitor, in which a first control capacitor provides a secondary voltage, from which a narrowband fundamental wave signal is derived and a second control capacitor provides a complete secondary signal; comparison means enclosed by the control means, to an input of which the narrowband fundamental wave signal is supplied as a control signal and to another input of which the complete secondary signal is supplied as a control signal, while the output signal operates the member with variable impedance, and in which the capacity of the control capacitors is much higher than the capacity of the other capacitors in the capacitive voltage divider.

19. Voltage divider according to claim 1 or 2, in which, in the series circuit, a high voltage capacitor is connected to the primary voltage, characterized by three parallel branches connected in series with the high voltage capacitor, the first branch of which comprises a capacitor while the other two branches each comprise at least two capacitors connected in series, one of each forms a control capacitor, in which a first control capacitor provides a s condary voltage from which a narrowband fundamental wave signal is derived and a second control capacitor provides a complete secondary signal, by comparison means comprised by the control means, to an input of which the narrowband fundamental wave signal is supplied as a control signal and to another input of which the complete secondary signal is supplied as a control signal, while the output signal controls the member with variable impedance, and in which the capacity of the single capacitor in the first branch is much higher than the capacity of the other capacitor in the alternating voltage divider and the total capacity of the two capacitors connected in series in the other parallel branches.

20. A voltage divider substantially as hereinbefore described with reference to Figs. 1, 6, 7, 8, 9, 10, 11 or 12 of the accompanying drawings.

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